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PHYSIOLOGICAL AND BIOLOGICAL PROPERTIES OF APO AND APS COTTON FLAME RETARDANTS

A LITERATURE REVIEW, WITH BIBLIOGRAPHY

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PHYSIOLOGICAL AND BIOLOGICAL PROPERTIES OF APO AND APS, COTTON FLAME RETARDANTS A LITERATURE REVIEW, WITH BIBLIOGRAPHY[1]

by

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General Information

Fatalities and permanent injuries due to burns have been studied by various sources, the general conclusion being that the hazard of textiles flaming, as a result of carelessness or other means, must be dealt with (1-5, 12, 13, 20, 44, 65).[3] The actual number of fatalities due to careless ignition of textiles can be only vaguely estimated (44). The English who have made intensive studies of the circumstances surrounding fatalities resulting from fires estimate that a large percentage are a result of accidental ignition of clothing, draperies, upholstery, etc. (14, 20, 65). It is understood, however, that hazards which cause the ignition of textile products are fewer in the United States than in England. A most significant finding in both countries is that children and the aged are particularly vulnerable to this hazard (3, 14, 20, 65).

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[1] The literature referred to in this review is reported only and no attempt has been made to interpret or evaluate the statements and claims in the articles. No responsibility is assumed for the accuracy, validity, or significance of the reported findings

[2] Located at New Orleans, La., one of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

[3] Numbers in parentheses refer to Bibliography, at end of report.

In the interest of safety, both civilian and military, and to improve the competitive position of cotton, work was undertaken at USDA's Southern Utilization Research and Development Division[4] to develop durable flame-retardant finishes for cotton fabrics. Many chemical compounds were investigated at the Southern Laboratory and the most effective was found to be tetrakis(hydroxymethyl)phosphonium chloride, referred to as THPC, in combination with tris(1-aziridinyl)phosphine oxide, APO, or in combination with tris(1-aziridinyl)phosphine sulfide, APS. After intensive testing and pilot plant trials, the Southern Laboratory chemists improved methods of manufacturing these chemicals and assisted in a large scale mill application of them to cotton textiles (32, 45, 46). The demonstrated superiority of these compounds as flame retardants has promoted active interest in industrial circles. Since these relatively unknown compounds are now being used on a semi-works or commercial scale, a survey of the literature was undertaken to ascertain what has been reported about the physiological and biological properties of APO and APS. THPC is already used commercially in other flameproofing formulations.

As is true of most industrial chemicals, APO and APS should be handled with reasonable care. However, after more than 2 years of experimental application of APO and APS to cotton goods in the Southern Division, and 7 years of experimental application of THPC, no serious or lasting effects have been observed among workers handling these compounds. A transient skin irritation, or dermatitis, can be caused by contact with APO or APS. However, this may be avoided by prompt and thorough washing of the contaminated skin area.

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[4] The Southern Division acknowledges with gratitude the support given to this work by the Quartermaster Research and Development Command, Natick, Mass. The Division is grateful also for the cooperation and help of Arnold L. Lippert, Ramon M. Esteve, Jr., and E. K. Kropa (Committee on Flame and Thermal Protective Clothing - National Academy of Sciences), Allan J. Quade of the Quartermaster, and George Buck and Leonard Smith of the National Cotton Council of America.

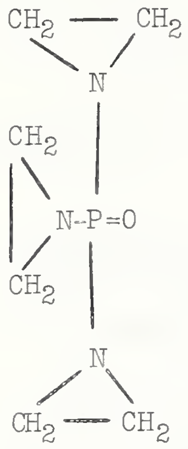
APO has been manufactured commercially for more than 2 years by the Farbwerke Hoechst AG[5/], and has been used in ton lots abroad in pigment printing (38). The Farbwerke reports (38) that it has experienced only occasional cases of dermatitis among printers handling APO, and even fewer cases among those handling APO during its manufacture, filling of containers, etc.

From reported experience abroad (38), and from tests run by the Agricultural Research Service, no evidence has been found which would indicate harmful effects resulting from contact of the skin with cotton fabrics treated with these materials and properly cured.

[5/] The mention of organizations and commercial products should not be construed as an endorsement of these by the U. S. Department of Agriculture over others not mentioned.

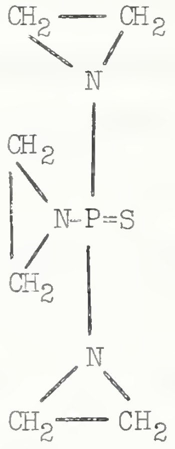
Physiological and Biological Properties of APO and APS

These highly reactive organo phosphorus compounds have the following respective structures:



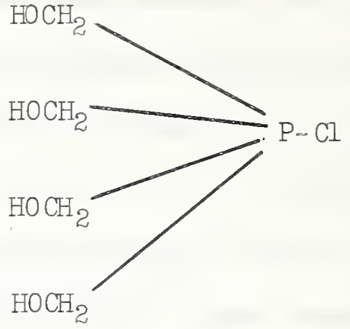
APO

tris(1-aziridinyl) phosphine oxide (also referred to as N,N',N"-triethylenephosphoramide, (TEPA)



APS

tris(1-aziridinyl) phosphine sulfide (also referred to as N,N',N"-triethylenethiophosphoramide (thio TEPA)



THPC

tetrakis(hydroxymethyl)phosphonium chloride

Considerable work on the physiological effects of APO and APS has been reported. These compounds were used experimentally in the treatment of certain types of leukemia, metastasizing mammary adenocarcinoma, a series of transplantable tumors in rats (including sarcoma 180), and a glioblastoma multiforme when used on rats and guinea pigs. The research has advanced to the point where APO and APS have been used in tests in the treatment of certain types of cancer in men and women. No references were found of these compounds being tested on the skin. However, there are many references to case histories in which administration of solutions of the compounds was oral, intramuscular, intravenous, intra-arterial, intrapleural, intraperitoneal, intracranial, by injection into the pericardium, and by instilling into the bladder (12).

A considerable number of investigators have used APO and APS and other ethylene amides in the experimental treatment of cancer. Articles reporting the results of these investigations in detail are included in the bibliography of this paper. In general, these investigators were encouraged to believe that APO, APS, and certain related materials have promise in combating certain forms of cancer. It is noteworthy, however, that none of these investigators reported results that would indicate that APO and APS are carcinogenic or unduly toxic and hazardous (8, 12, 21, 26, 27, 31, 43, 54-56, 63).

The compounds APO and APS have been screened for possible use as animal systemic insecticides, screw worm larvicides, and stable fly toxicants. APO and APS were ineffective against the arthropods. As a screw worm larvicide neither APO nor APS killed larvae when used in a 1% acetone solution whereas the standard, lindane, is effective in concentrations as low as 0.01%. As a stable fly toxicant neither APO nor APS produced 100% mortality at 1-week posttreatment whereas DDT is that effective in excess of 20 weeks (29).

APS was tested for possible uses as a herbicide in concentrations of 0.1 and 1.0 pound per acre on many test organisms such as beans, radish, oats, rice, etc. The results did not indicate any herbicidal activity (42).

APS was also used in the vapor phase action of chemicals against Penicillium spp. on oranges and lemons. Approximately 1 part of APS to 1,100 parts of air was used. The penicillium growth was equal to the standard comparative checks. There was no degree of injury and the odor was not objectionable (42).

In spite of the fairly large amount of work so far reported, not all of the physiological and biological properties of APO or APS are known as yet. Therefore it is necessary to exercise due care and caution in handling these chemicals.

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